

ANALYSIS OF ROUTING PROTOCOLS FOR A WIRED NETWORK

Thesis submitted in partial fulfillment of the requirements for the degree of

Bachelor in Technology

In

Computer Science and Technology

By

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Certificate

This is to certify that the work in the thesis entitled “Analysis of Routing Protocols for Wired Network” submitted by Sandeep Kumar Sahoo in partial fulfilment of the requirements for the **Award of the degree of Bachelor** of Technology in Computer Science and Engineering, **2010-2014** the department of Computer Science and Engineering, National Institute of Technology, Rourkela (Deemed University) is an authentic work carried out by him under my supervision and guidance.

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ACKNOWLEDGEMENT

I would like to express my earnest gratitude to my thesis guide, Prof. S Chinara for believing in my ability to work on the challenging domain of networks. Her profound insights has enriched my research work. The flexibility of work she has offered me has deeply encouraged me producing the research.

My heartfelt thanks to Prof. S Chinara for consistently showing me innovative research directions for the entire period of carrying out the research. I am indebted to all the professors, batch mates and friends at National Institute of Technology Rourkela for their cooperation.

I would conclude with my deepest gratitude to my parents, sister and all my loved ones. My full dedication to the work would have not been possible without their blessings and moral support.

SANDEEP KUMAR SAHOO

ABSTRACT

For communication to happen, data need to be transferred from source to the destination. So router is a device which helps in forwarding packets from one network to another or from one node to another in a network. For a router to work efficiently, some protocols are implemented such as the distance vectored and link state protocols which include RIP and OSPF protocols. The work is on the analysis of the routing protocols mainly for a wired network. The work focuses on the analysis of the routing protocols in a simulator and analysis of the routing table. The work also is to design a simulator that can find the best path to a given topology. The simulator should return the routing table for each node or router in the network which would contain the best path to reach the remote destination on the metric chosen based on the routing protocol implemented. For simulating the routing protocols the simulators used are OPNET and GNS3. Both the simulators support real world simulating capabilities. The analysis of routing protocols is done on these two simulators.

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ABBREBIATION

| | |
|-------|---|
| RIP | ROUTING INFORMATION PROTOCOL |
| OSPF | OPEN SHORTEST PATH FIRST |
| EIGRP | ENHANCED INTERIOR GATEWAY ROUTING PROTOCOL |
| IP | INTERNET PROTOCOL |
| AD | ADMINISTRATIVE DISTANCE |
| CPU | CENTRAL PROCESSING UNIT |
| OPNET | OPTIMIZED NETWORK ENGINEERING TOOL |
| GNS | GRAPHICAL NETWORK SIMULATOR |

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CHAPTER – 1

INTRODUCTION

The term routing ^[11] refers to tacking a packet from one device and sending it through the network to another device on a different network. Routers don't really care about the host, they only care about the networks and the best path to each network. The logical network address of the destination host is used to get packets to a network through a routes network, and then the hardware address of the host is used to deliver the packet from a router to the correct destination host.

A routing protocol ^[8] is used by routers to dynamically find all the networks in the internetwork and to ensure that all routers have the same routing table. Basically, a routing protocol determines the path of a packet through an internetwork. Examples of routing protocols are RIP, OSPF, and EIGRP. Once all the routers know about all networks, a routed protocol can be used to send user data in the form of packets through the established enterprise. Routed protocols are assigned to an interface and determine the method of packet delivery. Examples of routed protocols are IP and IPv6.

Routing protocols ^[8] are critical to a networks design. Dynamic routing protocols ^[3] run only on routers that use them in order to discover networks and update their routing tables. Using dynamic routing is easier for the system administrator, than using labor intensive, manually achieved, static routing method but it will cost in terms of router CPU process and bandwidth in the network links. The source of the increased bandwidth usage and CPU cycles is the operation of the dynamic routing protocol itself. A router running a dynamic routing protocol shares routing information with its neighboring routers, and it requires additional CPU cycles and additional bandwidth to accomplish that.

1.1 PROBLEM STATEMENT

The objective of this project is to

- Study routing protocols
- Simulate the routing protocols in a simulator
- Develop a simulator application which on input of a topology would return the routing table of all the nodes in the topology

CHAPTER – 2

LITERATURE REVIEW

2.1 ROUTING

2.1.1 IP ROUTING

IP routing ^[11] is the process of moving packets from one network to another network using routers. The IP routing process is important to understand because it pertains all routers and configurations that use IP. IP routing is used to forward packets from one node to other in the internetwork. IP routing is also used to determine the data has to follow to reach the destination node through the internetwork of nodes. The data is routed in the form of packets. The packets carries the data with informations of source and the destination addresses. IP routing enables a router to build a forwarding table or also called as a routing table to determine the next hop that the data packets should be sent in order to reach the destination node.

To be able to find all the networks in the internetwork and a path to reach each remote internetwork, a routing protocol is used. It is also used to ensure that all the routers in the internetwork have the same routing table. In general, a routing protocol determines the best path for a router to send packets to the remote network through an internetwork. Some examples of routing protocols includes Routing Information Protocol (RIP), Routing Information Protocol version 2 (RIPv2), Enhanced Interior Gateway Protocol (EIGRP) ^[3], and Open Shortest Path First (OSPF) ^[3].

Once after the routing table is build and all the routers has the information needed to reach to all the remote networks in the internetwork, data packets can be sent to the remote network using a routed protocol. A routed protocol is to an interface. Routed protocols helps in transferring packets from source to the destination using methods of packet delivery. Some examples of routed protocols includes Internet Protocol (IP).

2.1.2 ROUTING BASICS

To be able to route packets from source to the destination, a router should contain the following informations ^[14]: -

- Destination Address
- Neighbor routers from which it learns about all remote networks
- Possible routes to all remote networks
- The best route to each remote network
- How to maintain and verify routing information

The router needs to prepare a routing table which is a map of the interconnectivity of the nodes in the internetwork which contains details of which path to follow and how to reach the remote network. Such a map is built on the basis of the informations shared among the nodes in the internetwork configured in the same routing protocol. The administrator can also manually build the routing table.

Each and every nodes in the internetwork send and receive updates to build up the topology. For the adjacent nodes, the node has the path to reach it i.e. the exit interface to reach the neighbor node. If a node is not directly connected or is connected by a sequence of nodes then the node must find its way to the destination node. Such a node can find the required path information either by Static Routing or by Dynamic Routing. Static routing requires manually creation and updating of the routing table by the administrator by inserting all network information into each nodes. Dynamic Routing is better than Static Routing.

In the case of the Dynamic Routing, the nodes exchange details on the basis of the routing protocol configured in the node. This information is updated in the routing table. If any change occurs in the internetwork the sharing process starts and the information is exchanged until all the nodes are converged to the same routing table.

2.1.3 ADMINISTRATIVE DISTANCE

The administrative distance (AD) is used to rate the trustworthiness of routing information. The value depends on the information that a router receives from its neighbor routers. The Administrative Distance is a value which ranges from 0 to 255, where 0 means it is the most trusted and 255 means that it doesn't allow any traffic to pass through it.

If in case, a router receives more than one update from the same network, then the router which receives such updates checks for the AD value. The AD value for each update will differ and the router accepts only that AD value which is the lowest and this value is updated in the routing table of the router.

| ROUTE SOURCE | DEFAULT AD |
|-----------------------|------------|
| A connected interface | 0 |
| A static route | 1 |
| RIP | 120 |
| EIGRP | 90 |
| OSPF | 100 |

If a network is directly connected to a router, then that router will use the interface connected to the network always. If any routing protocol is configured in the router, then also the router chooses the connected interface as default as its AD value is less. If in the router multiple routing protocols are configured then on receiving updates from the same network with similar routing protocols then it chooses the least AD value.

For example, if the router has a static route, a RIP route and also an OSPF route to the same network, then the router will use the static route always by default.

2.1.4 ROUTING CLASSES

There are three different routing classes:-

2.1.4.1 Distance Vector

The distance vector ^[8] routing protocols configured in the router finds the best path to the remote network based on the distance from the router. The distance can be measured in the form of the hop count, which basically indicates the number of routers the data packet has to cross in order to get to the destination router. The vector in the Distance vector indicates the direction to the remote network. The distance vector routing protocols are class-full routing protocols. In such classes, full routing tables are exchanged and updates are exchanged through broadcast. e.g. - RIP, IGRP

2.1.4.2 Link State

The link state ^[9] routing protocols are also called as the shortest path first protocols. The link state routing protocols consist of three routing tables, neighbor table, topology table and the routing table. The neighbor table contains details of the directly connected routers. The topology table contains information about the topology of the entire internetwork. The routing table consists of the shortest path to the remote networks. The link state routing protocols are classless routing protocols. As compared to the distance vector, in the link state only the missing routes are exchanged. The updates are exchanged through multicast. e.g. – OSPF

2.1.4.3 Hybrid

The hybrid ^[8] protocols use the aspects of both the distance vector and the link state routing protocols. The hybrid protocols are classless routing protocols. In the case of hybrid protocols, only the missing routes are exchanged between the routers and the updates are exchanged through multicast. e.g. – EIGRP

2.1.5 ROUTING METRICS

The different routing metrics ^[10] includes the following: -

1. Hop count

The number of routers which a packet will pass before arriving at the destination router.

2. Cost

It is generally an arbitrary value that is assigned by the administrator and is based on the bandwidth

3. Bandwidth

It is the data capacity of the link.

4. Delay

It measures the total time taken by a packet to move from the source router to the destination router.

5. Load

It measures the amount of activity on a network source link a router or a link.

6. Reliability

It refers to the network link's bit error rate.

7. MTU

It stands for Maximum Transmission Unit. It resembles the maximum frame length in octets which is allowed to pass to the internetwork without fragmentation.

2.2 ROUTING PROTOCOLS

2.2.1 RIP [ROUTING INFORMATION PROTOCOL]

RIP ^[4] is an open standard routing protocol. It is a distance vectored routing protocols. It is a class-full routing protocol where updates are exchanged through broadcast. The routing table is exchanged every 30 seconds among the routers in the inter-network. The RIP protocol uses hop count as the metric to find the shortest path but the maximum allowable hop count is 15 by default. The RIP protocols is used only for a small network and is ineffective for a large network. The Administrative Distance of RIP is 120.

2.2.1.1 RIP TIMERS

To manage the routing performance, RIP uses four different kinds of timers:

- Update timer

It is the time interval after which a router sends it's a copy of the routing table as update to the neighbor routers. The update timer is 30 sec by default.

- Invalid timer

It is the time interval after which a router understands that the path to a network is invalid or becomes invalid. The invalid timer is 180 sec by default.

- Hold-down timer

It specifies the amount of time for which the information about the poorer routes are ignored. The hold-down timer is 180sec by default.

- Flush timer

It is the time before the invalid route is purged from the routing table. The flush timer is 240 sec by default.

2.2.1.2 Dis-advantages of RIP

- It uses more bandwidth as updates are exchanged every 30 seconds where each update contains the complete routing table of the router.
- It does not use bandwidth as the metric for calculation of the shortest path.
- RIP has a very slow convergence.
- RIP implementation can lead to routing loops in the network.
- RIP is only applicable to small network and is inefficient for larger networks.

2.2.2 OSPF [OPEN SHORTEST PATH FIRST]

Open Shortest Path First ^[4] is an open standard routing protocol. It is the successor of RIP routing protocol. It is a classless routing protocol. It works with link state advertisement and uses Dijkstra algorithm to find the shortest path. Here updates are exchanged through multicast i.e. 224.0.0.5. The administrative distance is 110 and the metric used by OSPF is the cost which is based on the bandwidth of the link. The cost is found by dividing the bandwidth in bps to 10^8 .

2.2.2.1 FEATURES: -

- Includes division into areas and autonomous systems.
- It minimizes the traffic by reducing update.
- It is scalable.
- It supports Variable Length Subnet Mask and Classless Inter-Domain Routing.
- Has maximum hop count of 255.
- It can be configured on different vendor routers.
- Faster convergence.
- Hello packets are sent every 10sec.
- Hierarchical design with multiple areas.

2.2.2.2 OSPF TABLES

The OSPF routing protocol has three tables: -

- Neighbor table
The neighbor table has the details about the nodes in the topology that are directly connected to the router i.e. the adjacent nodes.
- Database table
The database table has the details of the topology of the network i.e. how each node is connected to other nodes.
- Routing table
The routing table has the best path to reach each network in the internetwork on the basis of the protocol implemented in the router.

2.2.2.3 Dis-advantages of OSPF

- It consumes more memory.
- It consumes a lot of processing power.

CHAPTER – 3

SIMULATOR DESIGN

The propose task is to design a simulator application which on input of a topology would return the routing table of all the nodes in the topology. To be able to run the application, the topology has to be uploaded to the application and then simulated to provide output as routing tables.

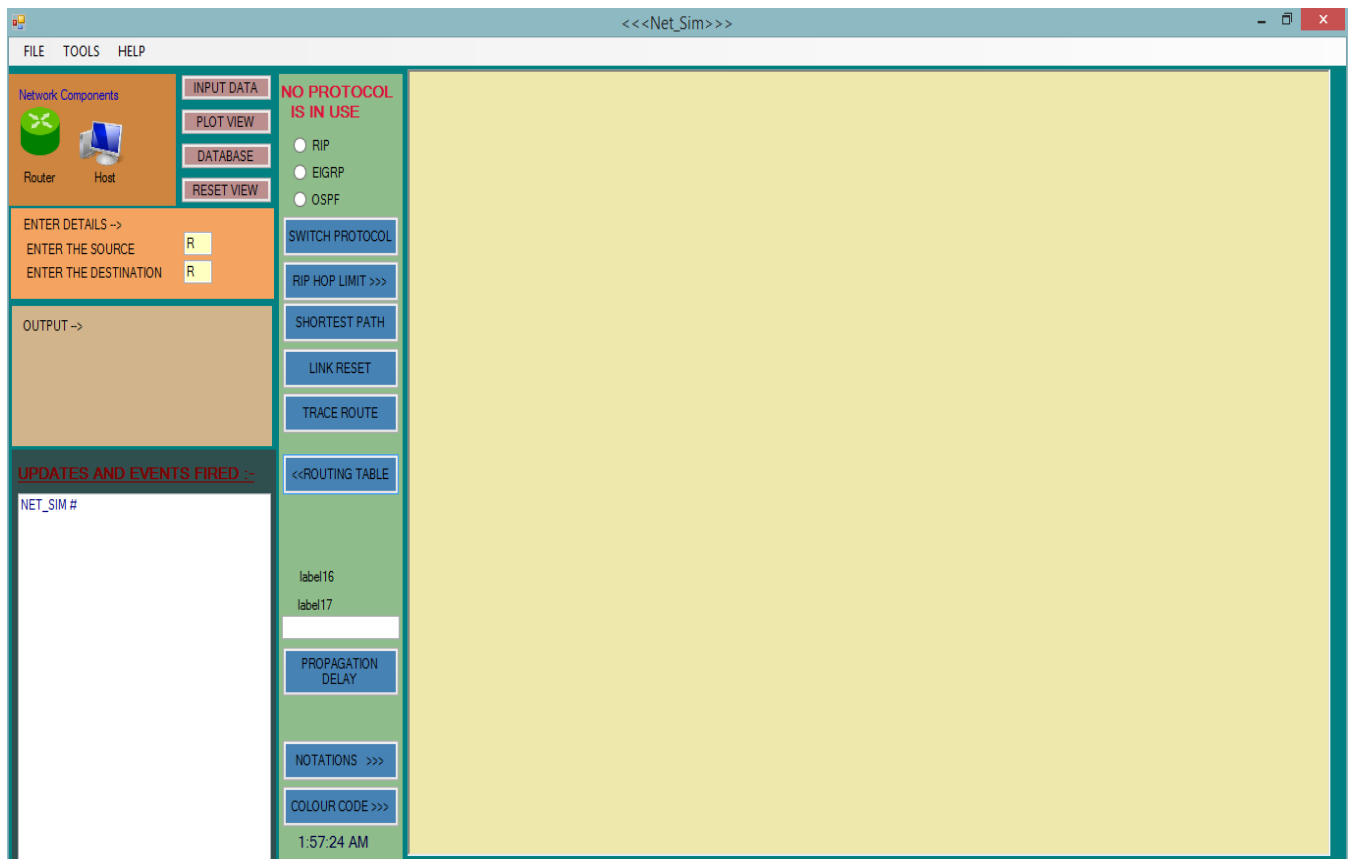


Figure 2.1: Application developed for simulation

For this, the input file contains details that need to be filled up in a sequential manner as follows: -

STEP 1: - [ROUTER DETAILS]

- Here, the total number of routers to be in the network is provided.
- On giving the total number of nodes/routers for a network, the simulator generates the default values of each router.
 - The default value contains information like Router ID
 - Router Name
 - Router Status
 - No of hosts connected
 - Router IP
 - No of serial ports
- The user can change the default values to the user defined values and can save to it.
- The user defined values need to be saved before going to the next step.

The screenshot shows a software window titled "Input Data" with a sidebar on the left and a main table area on the right. The sidebar contains four steps: STEP 1 (ROUTERS), STEP 2 (HOSTS DETAILS), STEP 3 (CONNECTIVITY), and STEP 4 (PROTOCOL). STEP 1 is active, showing a text input with the value "5" and a "View Details>>>" button. Below it are buttons for "Host Details", "Link Details", and "Protocol Choose". At the bottom of the sidebar are "HIDE" and "CLOSE" buttons. The main area displays a table with 6 columns: ROUTER ID, ROUTER NAME, STATUS, no. of HOSTS, ROUTER IP, and no. of SERIAL PORTS. The table contains 5 rows of data for routers R1 through R5. At the bottom of the main area are three buttons: "RESET", "SAVE", and "DELETE ALL".

| ROUTER ID | ROUTER NAME | STATUS | no. of HOSTS | ROUTER IP | no. of SERIAL PORTS |
|-----------|-------------|--------|--------------|-------------|---------------------|
| R1 | ROUTER1 | Active | 1 | 192.168.1.1 | 2 |
| R2 | ROUTER2 | Active | 1 | 192.168.2.1 | 2 |
| R3 | ROUTER3 | Active | 1 | 192.168.3.1 | 2 |
| R4 | ROUTER4 | Active | 1 | 192.168.4.1 | 2 |
| R5 | ROUTER5 | Active | 1 | 192.168.5.1 | 2 |

Figure 2.2: Enter details – router details

STEP 2: - [HOST DETAILS]

- Host details contains details about each hosts created for each and every router.
- It contains default values like
 - Connected to router ID
 - Host ID
 - Host Name
 - Status
 - Host IP
- Based on user requirements, details can be changed and every changes made has to be saved to move to further steps.

The screenshot shows a software interface titled "Input Data". On the left is a green sidebar with the heading "ENTER THE REQUIREMENTS" and a "<<" button. It contains four steps:

- STEP 1**: ROUTERS, with a text input "5" and a "View Details>>>" button.
- STEP 2**: HOSTS DETAILS, with a "View Details>>>" button.
- STEP 3**: CONNECTIVITY, with a "Link Details" button.
- STEP 4**: PROTOCOL, with a "Protocol Choose" button.

At the bottom of the sidebar are "HIDE" and "CLOSE" buttons. The main area has an orange background and displays a table of host details:

| ROUTER ID | HOST ID | HOST NAME | STATUS | HOST IP |
|-----------|---------|-----------|----------|-------------|
| R1 | PC11 | Host11 | Active ▼ | 192.168.1.2 |
| R2 | PC21 | Host21 | Active ▼ | 192.168.2.2 |
| R3 | PC31 | Host31 | Active ▼ | 192.168.3.2 |
| R4 | PC41 | Host41 | Active ▼ | 192.168.4.2 |
| R5 | PC51 | Host51 | Active ▼ | 192.168.5.2 |

Below the table are three buttons: "RESET", "SAVE", and "DELETE ALL".

Figure 2.3: Enter details – host details

STEP 3: - [LINK DETAILS]

- It contains two steps-
 - Connectivity
 - Bandwidth
- Connectivity
 - Here the user has to enter the topology i.e. how each router is connected to the other router
 - Connection is entered in the form of a matrix
 - Red - no connection
 - Green - connection
 - By default, it is red i.e. no connection. On a single click, the red change to green and a connection is established between the respected nodes.

Input Data

MANUAL MATRIX BANDWIDTH

ENTER THE REQUIREMENTS <<

STEP 1
ROUTERS 5 View Details>>

STEP 2
HOSTS DETAILS View Details>>

STEP 3
CONNECTIVITY View Details>>

STEP 4
PROTOCOL Protocol Choose

HIDE CLOSE

| | R1 | R2 | R3 | R4 | R5 |
|----|----|----|----|----|----|
| R1 | 0 | 1 | 0 | 0 | 1 |
| R2 | 1 | 0 | 1 | 0 | 0 |
| R3 | 0 | 1 | 0 | 1 | 0 |
| R4 | 0 | 0 | 1 | 0 | 1 |
| R5 | 1 | 0 | 0 | 1 | 0 |

| ROUTERS | R1 | R2 | R3 | R4 | R5 |
|---------|----|----|----|----|----|
| R1 | 0 | 1 | 0 | 0 | 1 |
| R2 | 1 | 0 | 1 | 0 | 0 |
| R3 | 0 | 1 | 0 | 1 | 0 |
| R4 | 0 | 0 | 1 | 0 | 1 |
| R5 | 1 | 0 | 0 | 1 | 0 |
| * | | | | | |

Figure 2.4: Enter details – link details and connectivity matrix

- Bandwidth
 - For a serial port, three different bandwidth values has been used and a user can assign any one of these three values to a link between the nodes.
 - By default, the link has a bandwidth of 64 kbps provided a connection exists.
 - The three different bandwidths: -
 - 64 kbps
 - 1544 kbps or 1.5 Mbps
 - 2000 kbps or 2 Mbps
 - On successive click events different bandwidths can be assigned to the links.

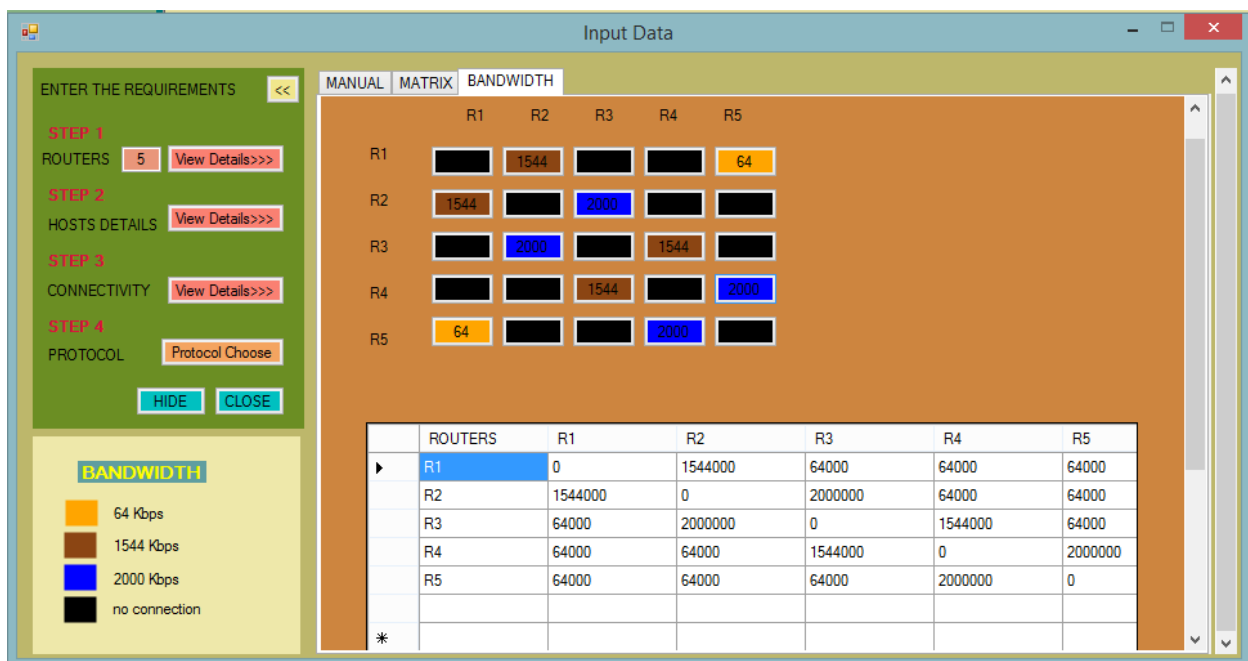


Figure 2.5: Enter details – Link bandwidth details

STEP 4: - [PROTOCOL CHOOSE]

- Here, the routing protocol is chosen: -
 - RIP
 - OSPF

Input Data

ENTER THE REQUIREMENTS <<

STEP 1
ROUTERS 5 View Details>>>

STEP 2
HOSTS DETAILS View Details>>>

STEP 3
CONNECTIVITY View Details>>>

STEP 4
PROTOCOL View Details>>>

HIDE CLOSE

BANDWIDTH

- 64 Kbps
- 1544 Kbps
- 2000 Kbps
- no connection

CHOOSE A ROUTING PROTOCOL

☒ RIPv1
☐ EIGRP
☐ OSPF

Select PROTOCOL CHOSEN IS RIP

Figure 2.6: Enter details – Choose routing protocol

STEP 5: - [PLOT TOPOLOGY]

The topology is created as a graphical representation: -

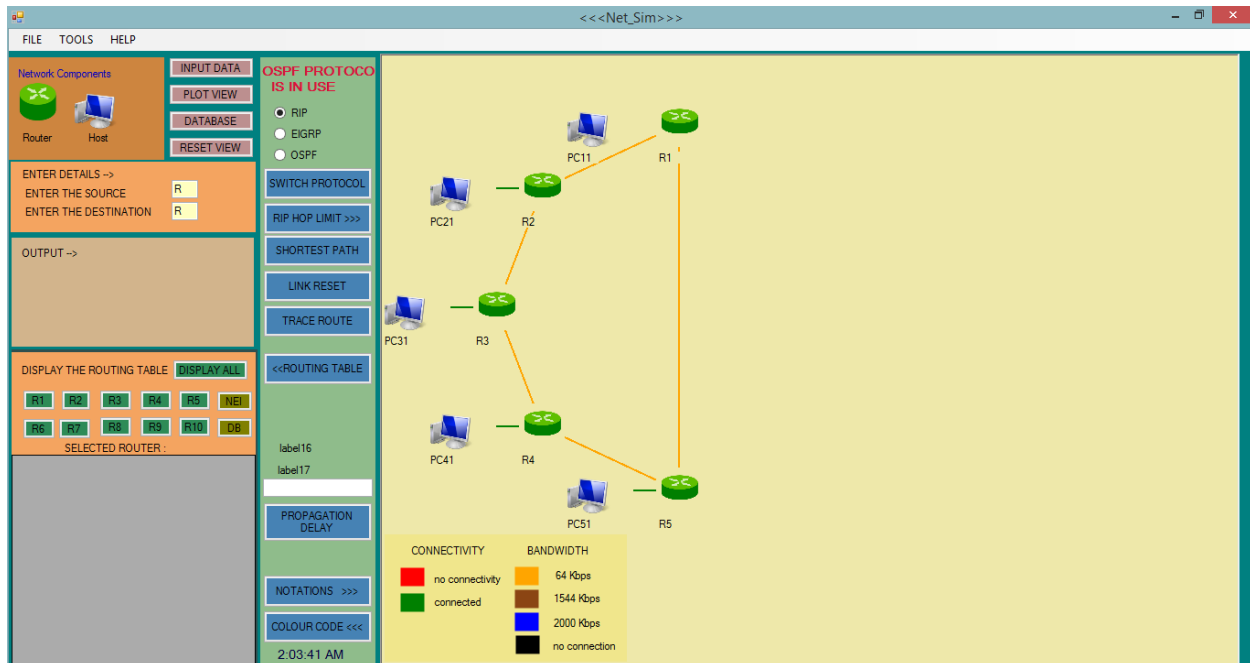


Figure 2.7: View the topology

CHAPTER – 4

IMPLEMENTATION

In this thesis, two platforms have been chosen to simulate two routing protocols. The two chosen simulators are GNS3 and OPNET. These two simulators are very helpful in simulating the real world scenario and can be used to debugging the real world network problems.

4.1 OPNET

OPNET ^[13] is a powerful software used to simulate heterogeneous network with various protocols. OPNET is a simulator built on top of discrete event system (DES) and it simulates behavior by modeling each event in the system and processes it through user defined processes. It allows hierarchical model. OPNET provides a comprehensive development environment to support the modelling system that can be analyzed by performing DES. In this thesis, the network simulator optimized network Engineering Tools (OPNET) modeler has been used as a simulation environment.

4.1.1 STRUCTURE OF OPNET

OPNET is built with huge number of library functions using C and C++ code. OPNET has a high end graphical interface. It also includes functionality of real time simulation graph plotting.

4.1.2 HIERARCHICAL STRUCTURE

The hierarchical structure ^[13] of OPNET model consists of three models:-

4.1.2.1 Network Domain

The network domain consists of the physical interconnection and the configuration of the different nodes included in the topology of the internetwork. It represents the complete structure of the topology on a map to be simulated.

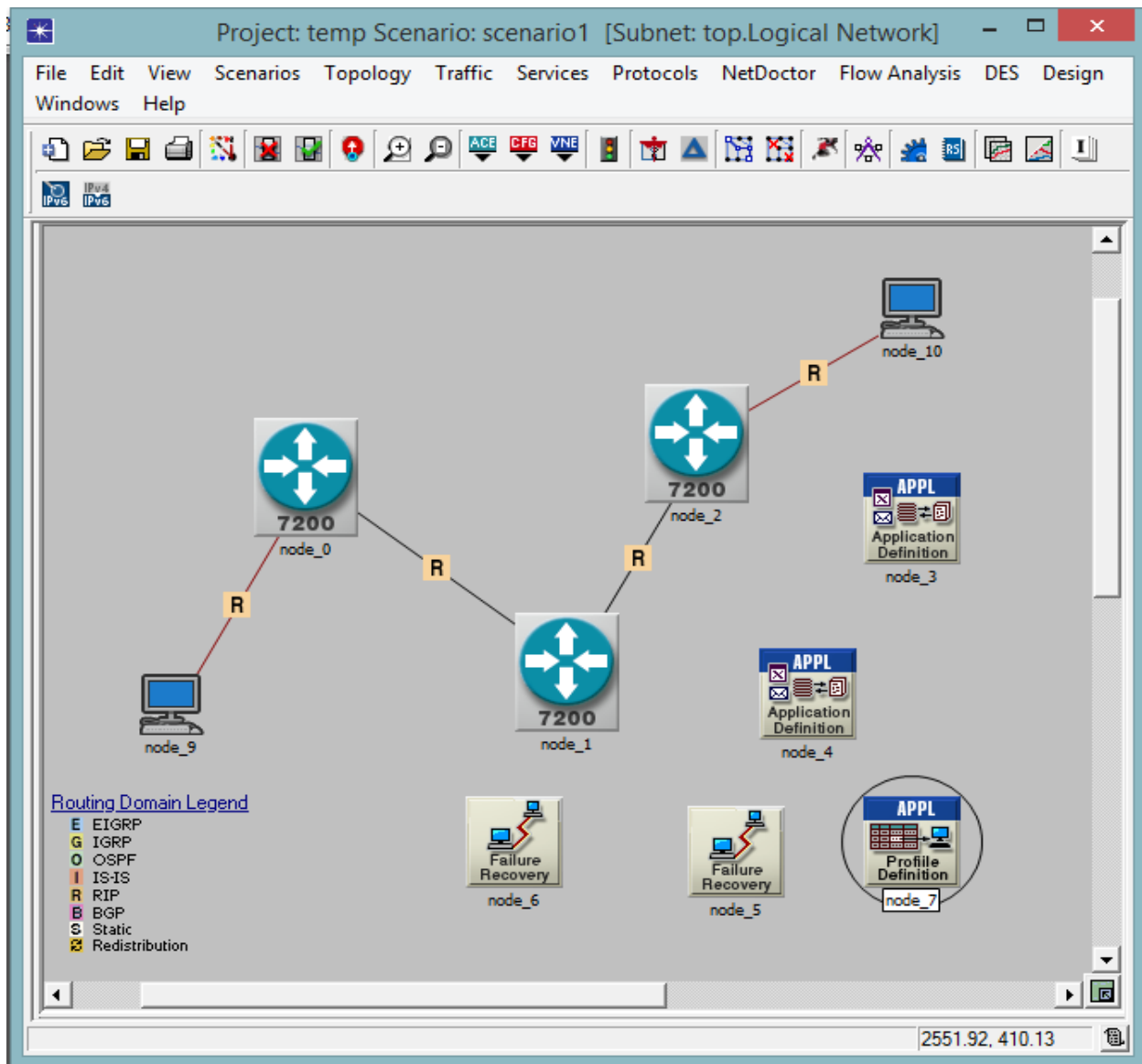


Figure 4.1: OPNET Simulator – Network Domain

4.1.2.2 Node Domain

The Node Domain of the network domain consists of the internal infrastructure of the internetwork. The nodes can be routers, workstations, satellite and so on.

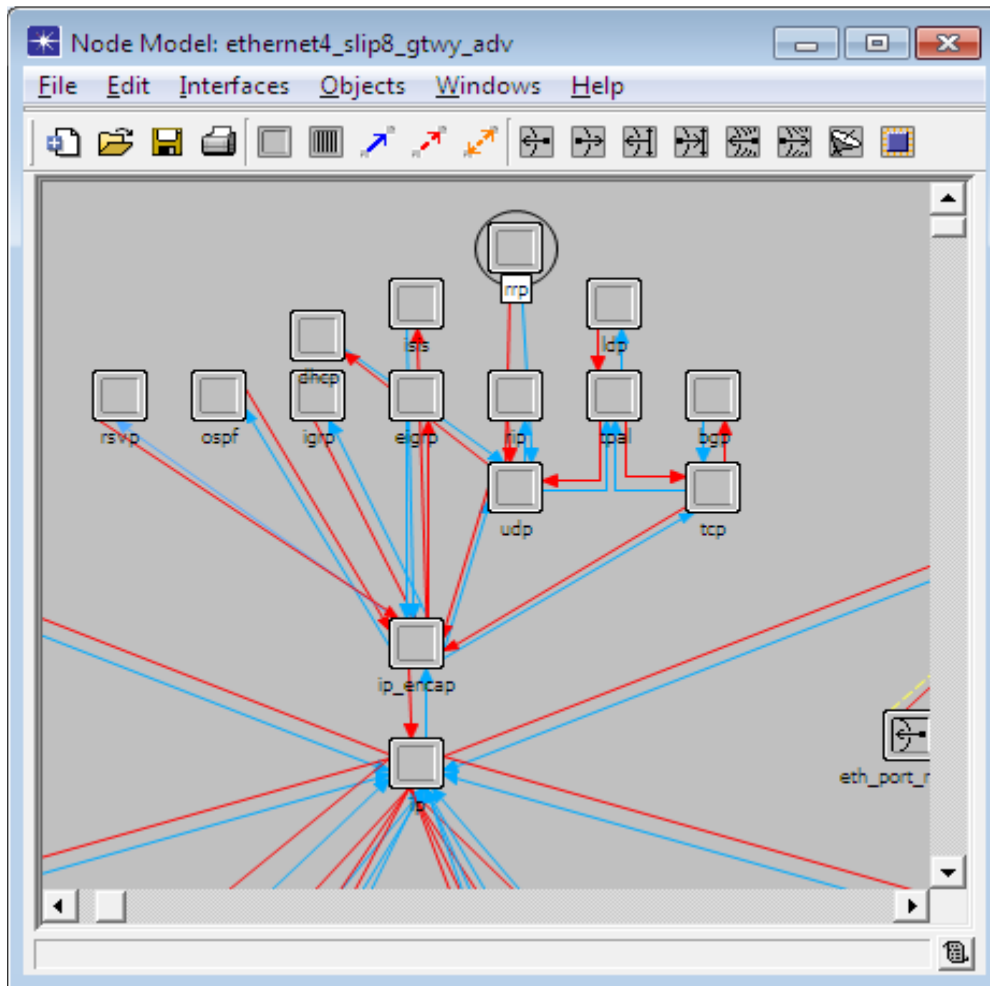


Figure 4.2: OPNET Simulator – Node Domain

4.1.2.3 Process Domain

Process Domain are used to specify the attribute of the processor and square model by using source code C and C++ which is inside the node models.

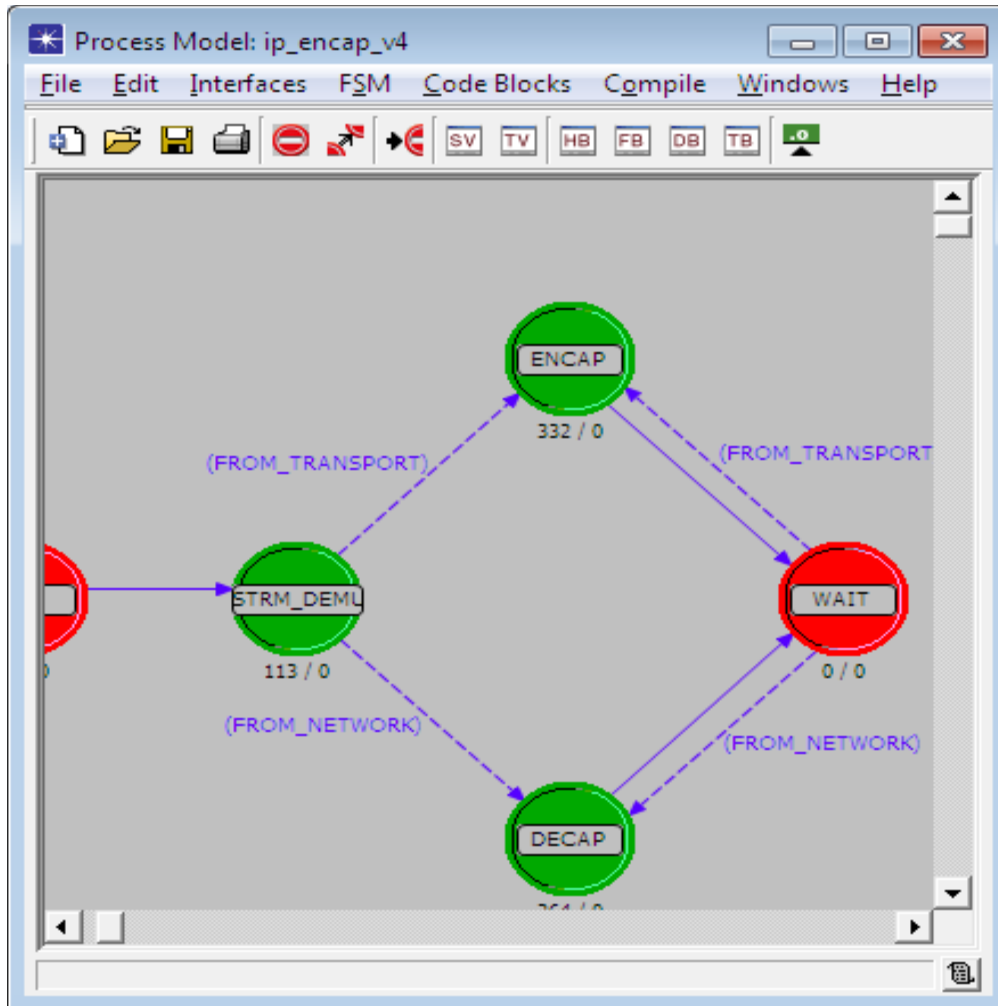


Figure 4.3: OPNET Simulator – Process Domain

4.1.3 SIMULATION STUDY

The protocols used in the thesis are RIP and OSPF. These two protocols are used to find the best path for a packet to travel from source to the destination. In the simulator OPNET, we simulate these two protocols for a particular topology and find the routing table for the network. The routing table gives the shortest path to reach the destination on the basis of the protocol implemented and the metric that the routing protocol uses.

4.1.4 NETWORK TOPOLOGY

The topology used in consists of the routers and different networks connected to each other. The topology contains four router connected to different networks.

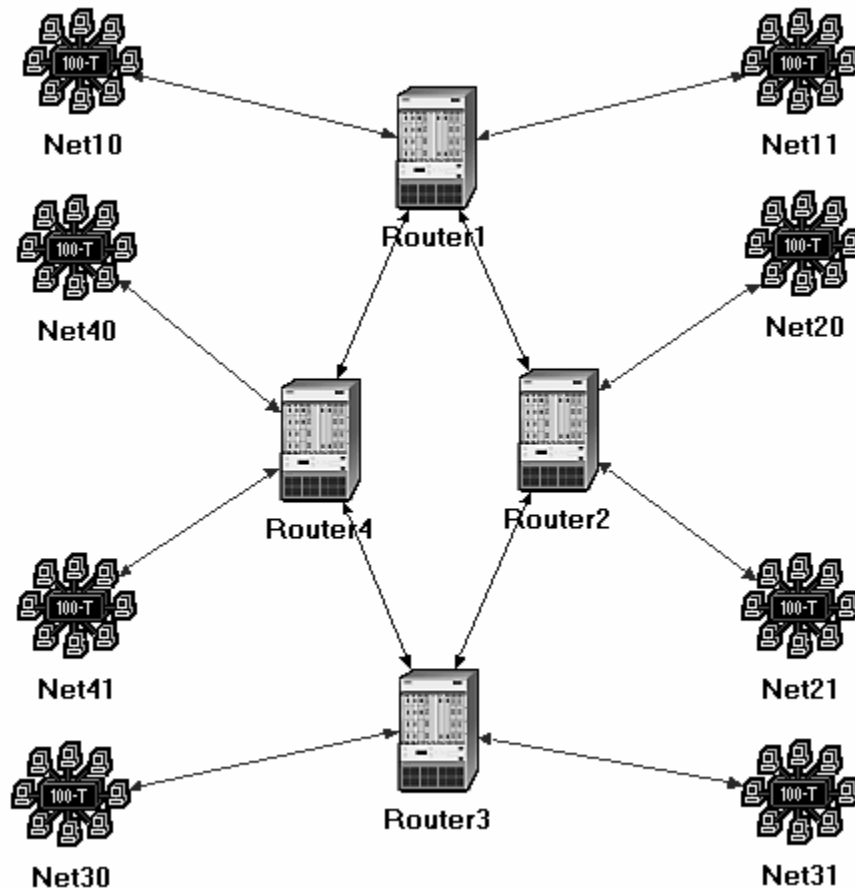


Figure 4.4: OPNET Simulator – Network Topology

4.1.5 PROTOCOL SCENARIO

The topology of the network for the simulation of the two routing protocols i.e. RIP and OSPF consists of 5 nodes where each node represents to be the gateway node to a different network. The five different nodes are connected to each other in a manner as shown in the diagram.

4.2 GNS3

GNS3 ^[12] is an open source software that helps simulate the complex networks as close as possible to the way real networks perform and such is achieved without having dedicated network hardware such as routers and switches.

This software provides an intuitive graphical user interface to design and configure virtual networks, it runs on traditional PC hardware and may be used on multiple operating systems, including Windows, Linux, and MacOS X.

In order to provide a complete and an accurate simulations, the GNS3 actually uses the following emulators to run the very same operating systems as in real networks:

- Dynamips, the well-known Cisco IOS emulator.
- VirtualBox, runs desktop and server operating systems as well as Juniper JunOS.
- Qemu, a generic open source machine emulator, it runs Cisco ASA, PIX and IPS.

4.2.1 MODES IN GNS3

There are two modes ^[12] of working in the GNS3 simulator: -

4.2.1.1 Design mode

By default, GNS3 starts in design mode. In this mode, one can create a topology design in graphical manner. To do one must drag a specific node from the left where there is list of other networking device and drop in the design area and then connect the different devices to form a topology.

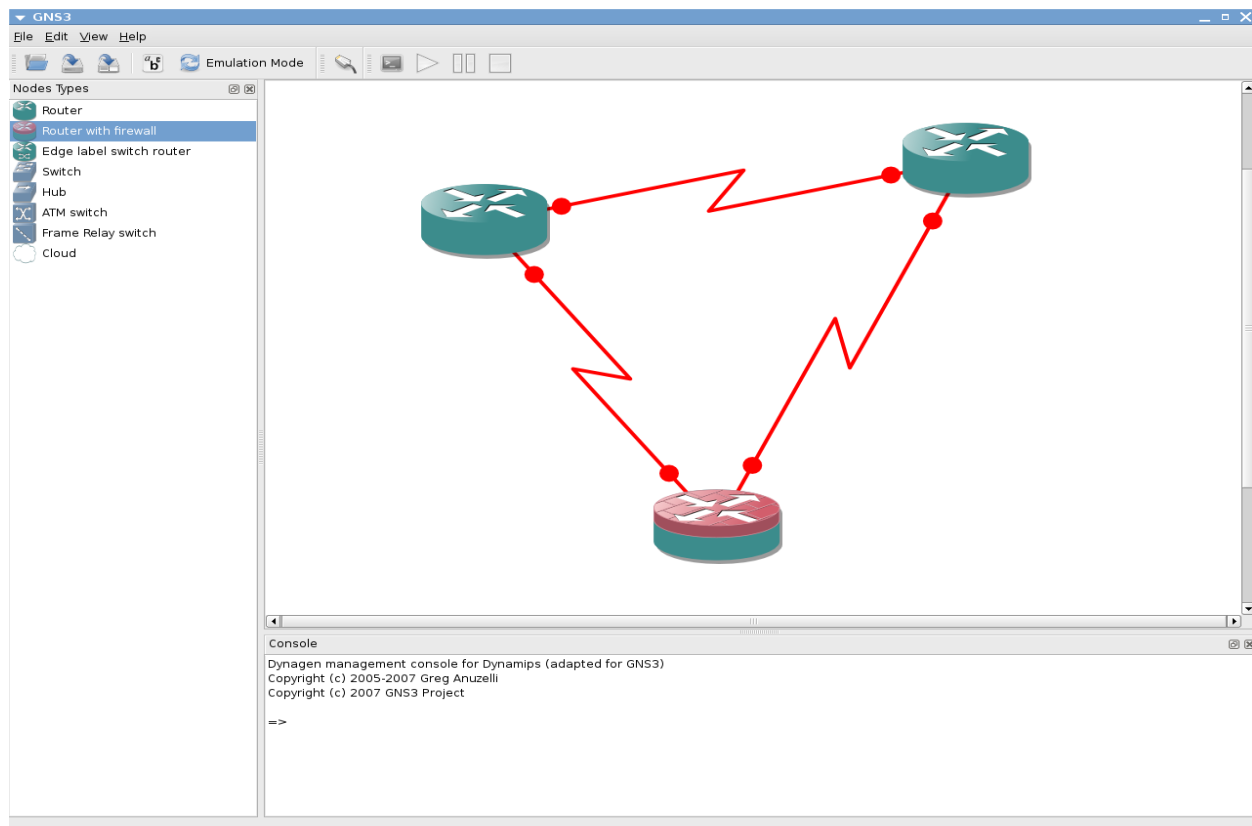


Figure 4.5: GNS3 Simulator – Design Mode

4.2.1.2 Emulation mode

After one has designed the topology, one can switch over to the next mode by selecting the Emulation mode in the menu bar. On selecting the Emulation mode, all the setting saved or configured in each nodes will be visible in the design area of the simulator. One can start, stop or suspend an IOS instance by right clicking on a node. After connecting with the console to the routers, we can assign IP addresses to the serial interfaces.

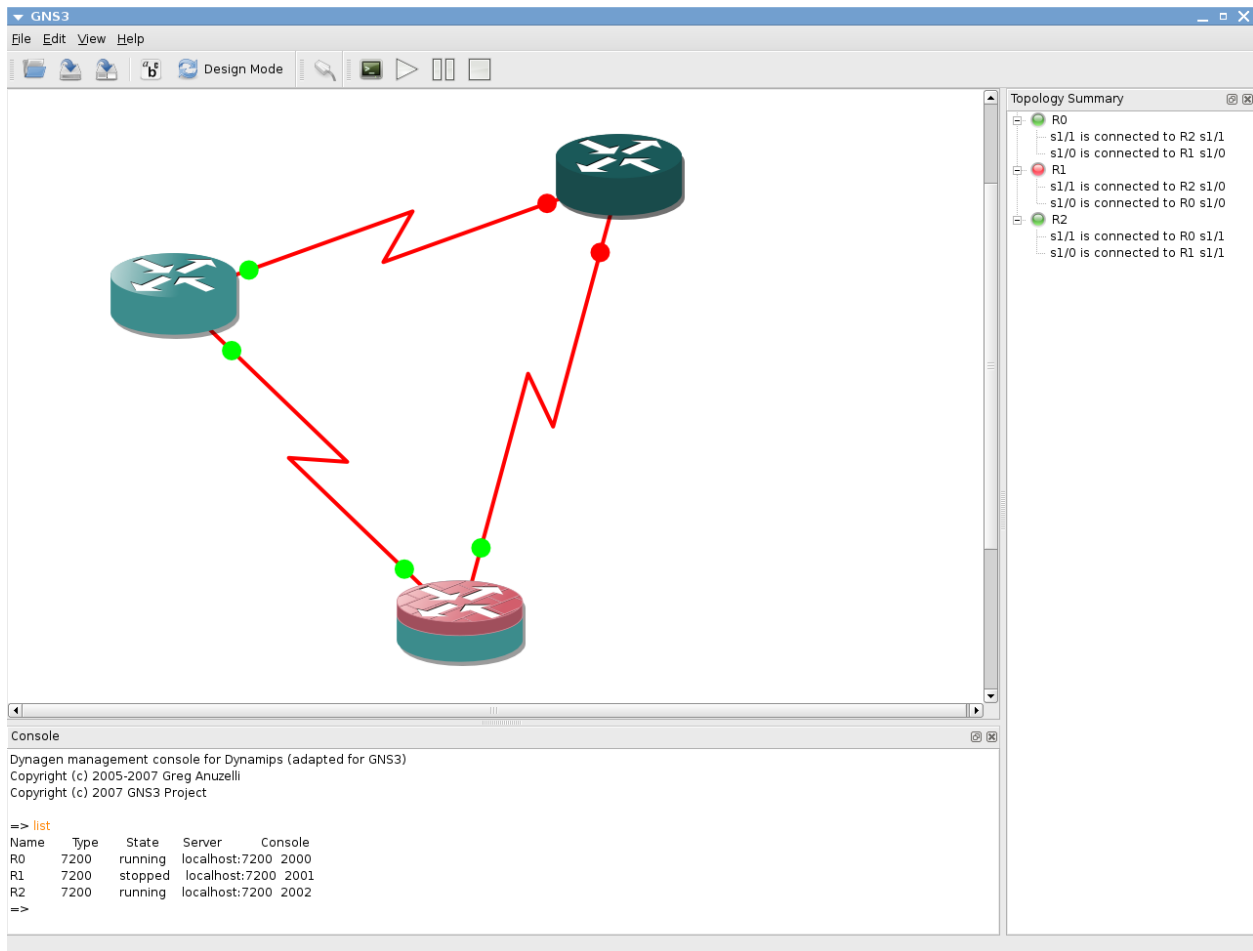


Figure 4.6: GNS3 Simulator – Emulation Mode

4.2.2 NETWORK TOPOLOGY SCENARIO

The topology of the network for the simulation of the two routing protocols i.e. RIP and OSPF consists of 5 nodes where each node represents to be the gateway node to a different network. The five different nodes are connected to each other in a manner as shown in the diagram.

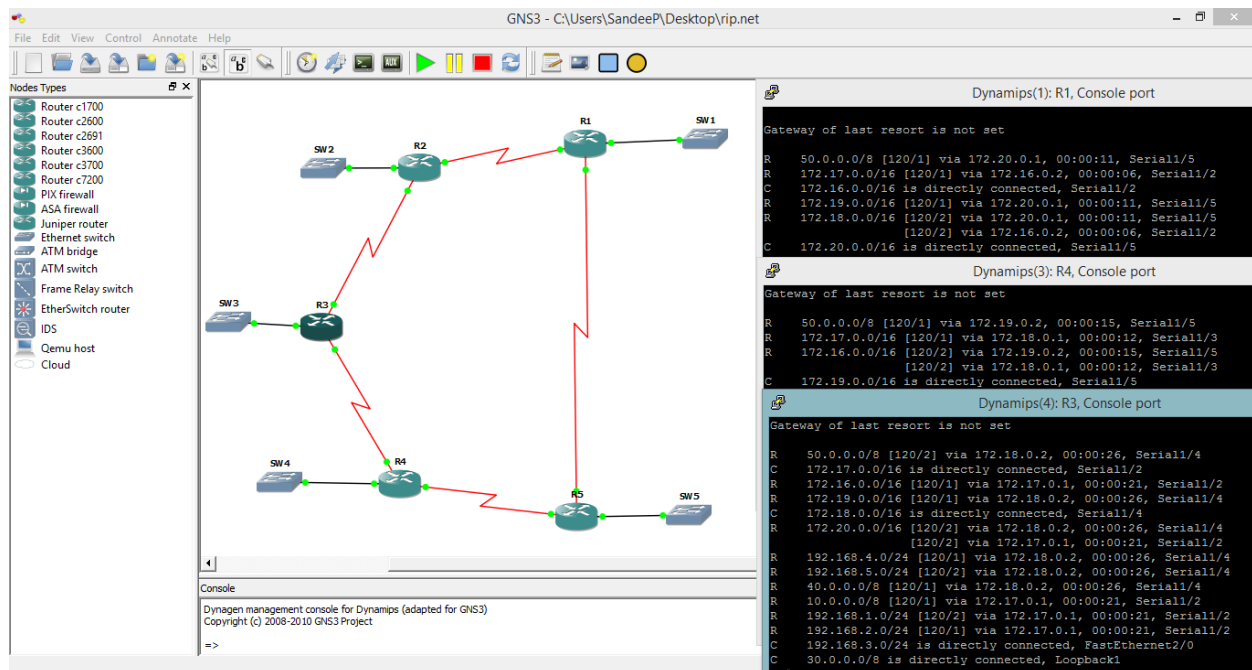


Figure 4.7: GNS3 Simulator – Network Topology

4.2.3 PROTOCOL SCENARIO

On the topology selected and routers are configured to be connected to others and the interfaces are configured. After such step, protocol is configured. On the basis of the protocol chosen for implementation the path varies and the routing table varies. The routing table for the routers for different protocol implementation is give in details in the result and analysis section

CHAPTER – 5

RESULT AND ANALYSIS

This section of the thesis shows the results and analysis that have been concluded from the implementation of the routing protocols in the network based simulators. The result mainly deals with the analysis of the routing table of the routers in the internetwork. The analysis of the results for each simulator on which the routing protocols has been implemented are: -

5.1 New_Simulator (designed and developed for the thesis)

The topology used in the analysis of the routing table consists of five routers connected in the form of a circle. The routers are connected to each other by serial ports. The serial ports are the ports through which one router is connected to another router. In this simulator, two routing protocols has been implemented. Among the two routing protocols, one is RIP and the other is OSPF. The result which includes the routing table of each routers for each protocol implemented are given as follows: -

5.1.1 PROTOCOL --- RIP

The routing table for router R1 is

| SELECTED ROUTER : R1 | | | |
|----------------------|-----------|-----------|-----------|
| NETWORK | EXIT INTF | CONN TYPE | HOP COUNT |
| 192.168.1.0 | eth0 | C | 0 |
| 192.168.2.0 | S2 | R | 1 |
| 192.168.3.0 | S2 | R | 2 |
| 192.168.4.0 | S5 | R | 2 |
| 192.168.5.0 | S5 | R | 1 |
| | | | |

Figure 5.1: New_Simulator – Routing Table for R1 using RIP

The routing table for R4 is

| SELECTED ROUTER : R4 | | | |
|----------------------|-----------|-----------|-----------|
| NETWORK | EXIT INTF | CONN TYPE | HOP COUNT |
| 192.168.1.0 | S5 | R | 2 |
| 192.168.2.0 | S3 | R | 2 |
| 192.168.3.0 | S3 | R | 1 |
| 192.168.4.0 | eth0 | C | 0 |
| 192.168.5.0 | S5 | R | 1 |
| | | | |

Figure 5.2: New_Simulator – Routing Table for R4 using RIP

The routing table displays the details of all the five networks and the minimum hop count to reach the network and the exit interface of the router including the connection type. The connection type, R indicates RIP connection and C indicates directly connected networks respectively.

5.1.2 PROTOCOL --- OSPF

The routing table for router R1 is

| SELECTED ROUTER : R1 | | | |
|----------------------|-----------|------|------|
| NETWORK | EXIT INTF | COST | CONN |
| 192.168.1.0 | eth0 | 0 | C |
| 192.168.2.0 | S2 | 65 | O |
| 192.168.3.0 | S2 | 115 | O |
| 192.168.4.0 | S2 | 179 | O |
| 192.168.5.0 | S5 | 1563 | O |
| | | | |

Figure 5.3: New_Simulator – Routing Table for R1 using OSPF

The routing table gives the details of the routing table for the router R1 which contains details of how to reach to the destination. The details included are the networks ip address, the exit interface of the router, cost to reach the network and the connection type. The connection type, O indicates OSPF protocol implementation. The cost is calculated by dividing 10^8 by the bandwidth in bps. The minimum cost to the particular network find it place in the routing table.

The neighbor table of the router R1 is

| SELECTED ROUTER : R1 | |
|----------------------|-----------|
| NEI ID | EXIT INTF |
| R2 | S2 |
| R5 | S5 |
| | |
| | |
| | |
| | |

Figure 5.4: New_Simulator – Neighbor Table for R1 using OSPF

The neighbor table contains details of the router which are directly connected to the host router and it also gives the exit interface of the host router to reach the destination router. As router R1 is directly connected to router R2 and R5, so the neighbor table consists of two inputs i.e. the router R2 and the router R5 and it also includes information about the exit interface to reach the destination router.

5.2 OPNET

The OPNET simulator is used to find the routing table and also show the path followed by the packet through the topology to reach the destination router. It gives a graphical representation of the shortest path as per the protocol implemented in the router.

5.2.1 PROTOCOL --- RIP

The routing table provides details for the path to be followed to reach the destination router in the best possible shortest path available. It includes details like the destination network address, subnet mask, next hop ip address, exit interface name, metric and the protocol used.

| Router name: Campus Network.Router1 at time: 600.00 seconds | | | | | |
|--|---------------|-----------|----------------|--------|----------|
| ROUTE TABLE contents: | | | | | |
| Dest. Address | Subnet Mask | Next Hop | Interface Name | Metric | Protocol |
| 192.0.0.0 | 255.255.255.0 | 192.0.0.1 | IF0 | 0 | Direct |
| 192.0.1.0 | 255.255.255.0 | 192.0.1.1 | IF1 | 0 | Direct |
| 192.0.2.0 | 255.255.255.0 | 192.0.2.1 | IF10 | 0 | Direct |
| 192.0.3.0 | 255.255.255.0 | 192.0.3.1 | IF11 | 0 | Direct |
| 192.0.4.0 | 255.255.255.0 | 192.0.4.1 | Loopback | 0 | Direct |
| 192.0.11.0 | 255.255.255.0 | 192.0.3.2 | IF11 | 1 | RIP |
| 192.0.13.0 | 255.255.255.0 | 192.0.3.2 | IF11 | 1 | RIP |
| 192.0.14.0 | 255.255.255.0 | 192.0.3.2 | IF11 | 1 | RIP |
| 192.0.15.0 | 255.255.255.0 | 192.0.3.2 | IF11 | 1 | RIP |
| 192.0.5.0 | 255.255.255.0 | 192.0.3.2 | IF11 | 3 | RIP |
| 192.0.6.0 | 255.255.255.0 | 192.0.3.2 | IF11 | 3 | RIP |
| 192.0.7.0 | 255.255.255.0 | 192.0.3.2 | IF11 | 2 | RIP |
| 192.0.8.0 | 255.255.255.0 | 192.0.3.2 | IF11 | 3 | RIP |
| 192.0.9.0 | 255.255.255.0 | 192.0.3.2 | IF11 | 2 | RIP |
| 192.0.10.0 | 255.255.255.0 | 192.0.3.2 | IF11 | 2 | RIP |
| 192.0.12.0 | 255.255.255.0 | 192.0.3.2 | IF11 | 2 | RIP |

Figure 5.5: OPNET Simulator – Routing Table

52.2 PROTOCOL --- OSPF

In case of OSPF routing protocol in OPNET, we provide details to find the shortest path from router A to router C, and the path found is Router A to router D to router E and at last to router C.

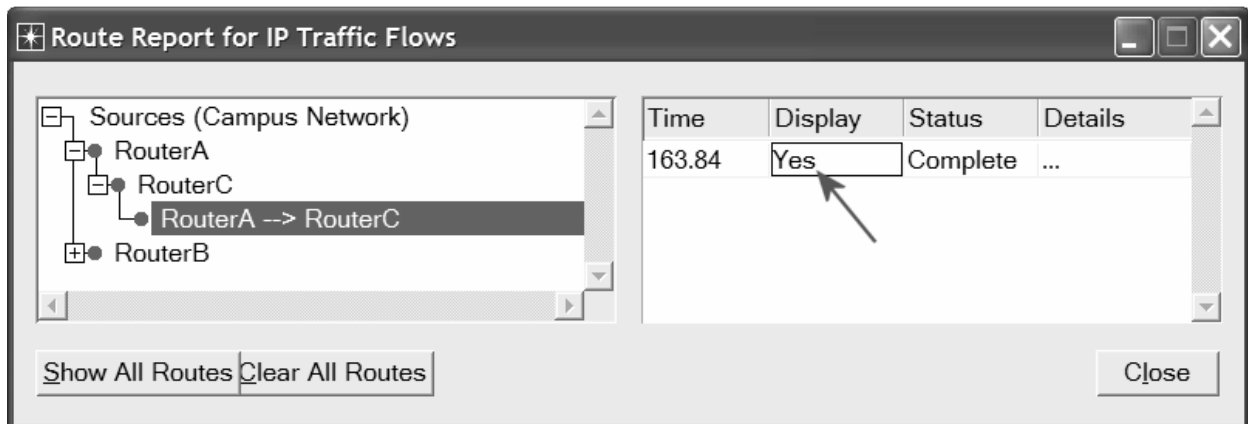


Figure 5.6: OPNET Simulator – Route Report

The path is displayed as in the following diagram:

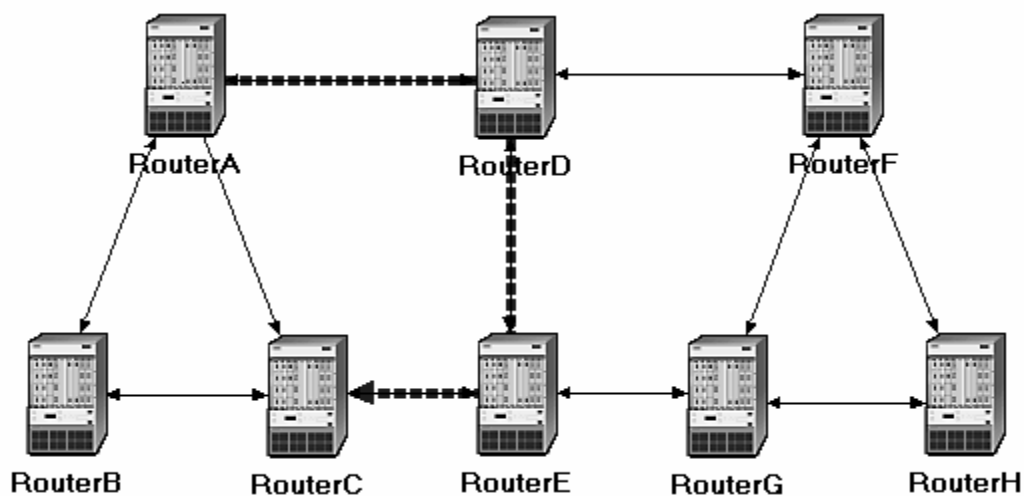


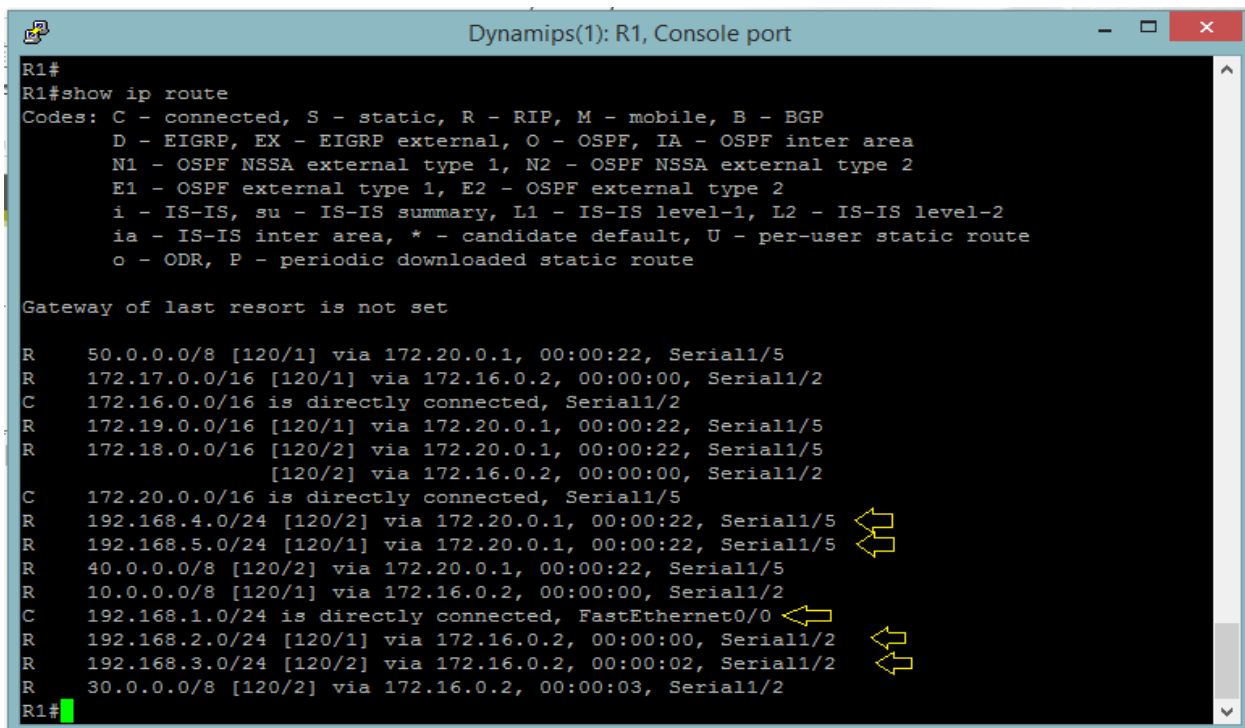
Figure 5.7: OPNET Simulator – Routing Path

5.3 GNS3

The topology used in the analysis of the routing table consists of five routers connected in the form of a circle. The routers are connected to each other by serial ports. The serial ports are the ports through which one router is connected to another router. In this simulator, two routing protocols has been implemented. Among the two routing protocols, one is RIP and the other is OSPF. The result which includes the routing table of each routers for each protocol implemented are given as follows: -

5.3.1 PROTOCOL --- RIP

The routing table for the router R1 and the router R4 are given below



```
R1#
R1#show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is not set

R    50.0.0.0/8 [120/1] via 172.20.0.1, 00:00:22, Serial1/5
R    172.17.0.0/16 [120/1] via 172.16.0.2, 00:00:00, Serial1/2
C    172.16.0.0/16 is directly connected, Serial1/2
R    172.19.0.0/16 [120/1] via 172.20.0.1, 00:00:22, Serial1/5
R    172.18.0.0/16 [120/2] via 172.20.0.1, 00:00:22, Serial1/5
       [120/2] via 172.16.0.2, 00:00:00, Serial1/2
C    172.20.0.0/16 is directly connected, Serial1/5
R    192.168.4.0/24 [120/2] via 172.20.0.1, 00:00:22, Serial1/5
R    192.168.5.0/24 [120/1] via 172.20.0.1, 00:00:22, Serial1/5
R    40.0.0.0/8 [120/2] via 172.20.0.1, 00:00:22, Serial1/5
R    10.0.0.0/8 [120/1] via 172.16.0.2, 00:00:00, Serial1/2
C    192.168.1.0/24 is directly connected, FastEthernet0/0
R    192.168.2.0/24 [120/1] via 172.16.0.2, 00:00:00, Serial1/2
R    192.168.3.0/24 [120/2] via 172.16.0.2, 00:00:02, Serial1/2
R    30.0.0.0/8 [120/2] via 172.16.0.2, 00:00:03, Serial1/2
R1#
```

Figure 5.8: GNS3 Simulator – Routing Table for R1 [RIP]


```
Dynamips(3): R4, Console port
R4#
R4#sh ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is not set

R    50.0.0.0/8 [120/1] via 172.19.0.2, 00:00:10, Serial1/5
R    172.17.0.0/16 [120/1] via 172.18.0.1, 00:00:02, Serial1/3
R    172.16.0.0/16 [120/2] via 172.19.0.2, 00:00:10, Serial1/5
       [120/2] via 172.18.0.1, 00:00:02, Serial1/3
C    172.19.0.0/16 is directly connected, Serial1/5
C    172.18.0.0/16 is directly connected, Serial1/3
R    172.20.0.0/16 [120/1] via 172.19.0.2, 00:00:10, Serial1/5
C    192.168.4.0/24 is directly connected, FastEthernet2/0
R    192.168.5.0/24 [120/1] via 172.19.0.2, 00:00:10, Serial1/5
C    40.0.0.0/8 is directly connected, Loopback0
R    10.0.0.0/8 [120/2] via 172.18.0.1, 00:00:02, Serial1/3
R    192.168.1.0/24 [120/2] via 172.19.0.2, 00:00:10, Serial1/5
R    192.168.2.0/24 [120/2] via 172.18.0.1, 00:00:02, Serial1/3
R    192.168.3.0/24 [120/1] via 172.18.0.1, 00:00:04, Serial1/3
R    30.0.0.0/8 [120/1] via 172.18.0.1, 00:00:05, Serial1/3
R4#
```

Figure 5.9: GNS3 Simulator – Routing Table for R4 [RIP]

The routing table shows the details of the routing table for all the remote networks in the entire internetwork as:

E.g.-<<R 192.168.3.0/24 [120/1] via 172.18.0.1, 00:00:04, Serial1/3>>

R --- RIP protocol in use

192.168.3.0/24 --- network ip with subnet mask

120 --- RIP protocol AD value

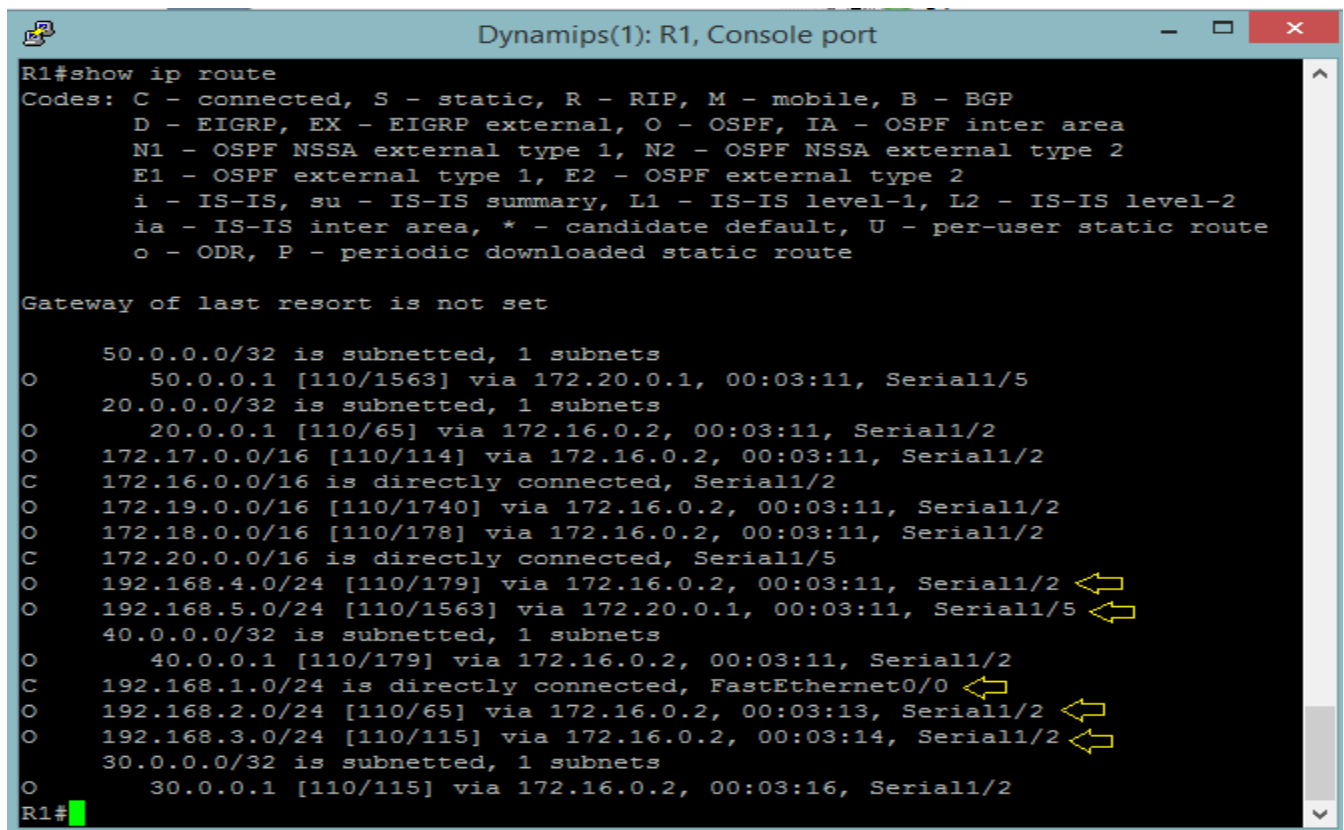
1 --- Hop count

172.18.0.1 --- exit interface ip

Serial1/3 --- exit interface

5.3.2 PROTOCOL --- OSPF

The routing table for router R1 is



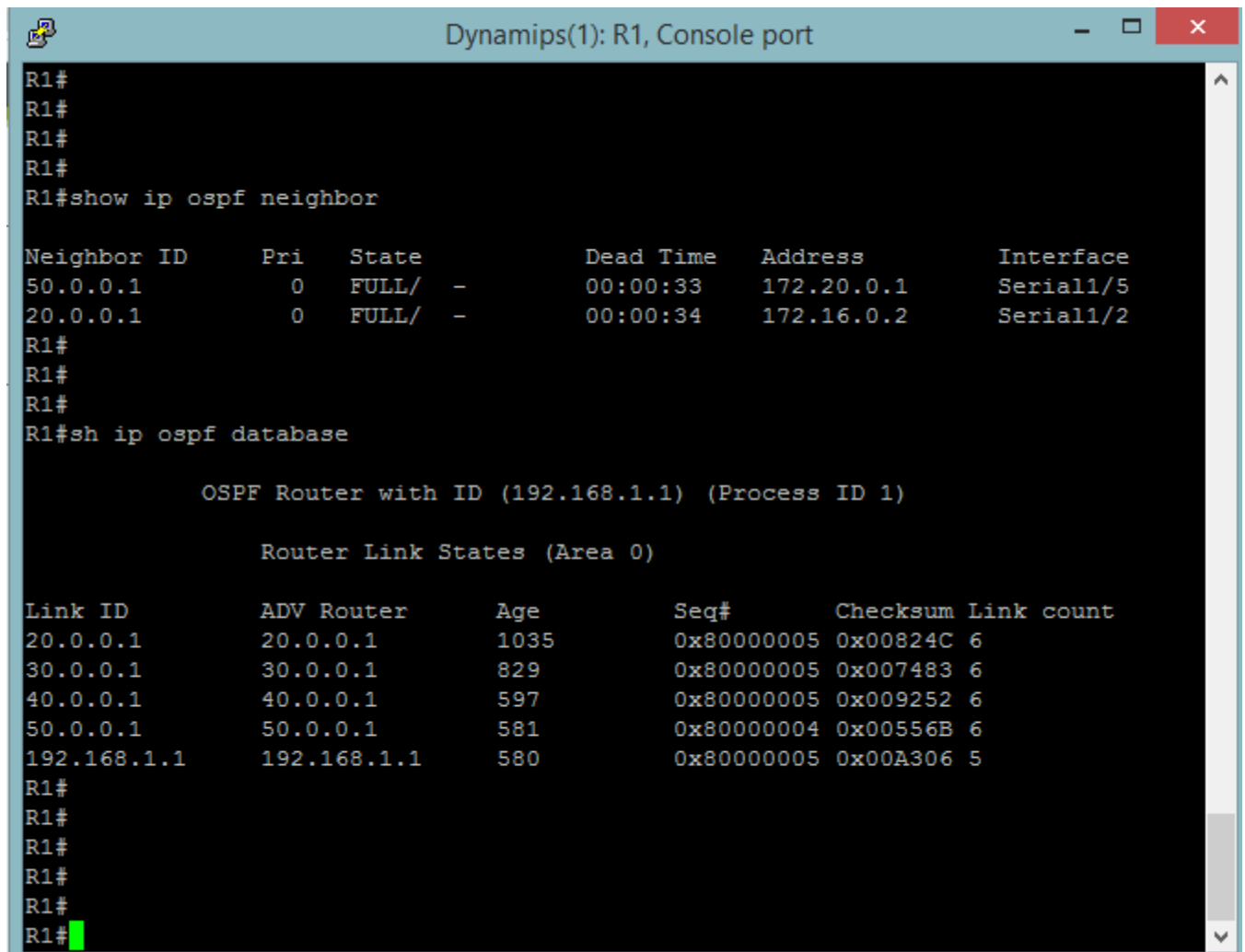
```
R1#show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is not set

 50.0.0.0/32 is subnetted, 1 subnets
O    50.0.0.1 [110/1563] via 172.20.0.1, 00:03:11, Serial1/5
 20.0.0.0/32 is subnetted, 1 subnets
O    20.0.0.1 [110/65] via 172.16.0.2, 00:03:11, Serial1/2
O    172.17.0.0/16 [110/114] via 172.16.0.2, 00:03:11, Serial1/2
C    172.16.0.0/16 is directly connected, Serial1/2
O    172.19.0.0/16 [110/1740] via 172.16.0.2, 00:03:11, Serial1/2
O    172.18.0.0/16 [110/178] via 172.16.0.2, 00:03:11, Serial1/2
C    172.20.0.0/16 is directly connected, Serial1/5
O    192.168.4.0/24 [110/179] via 172.16.0.2, 00:03:11, Serial1/2
O    192.168.5.0/24 [110/1563] via 172.20.0.1, 00:03:11, Serial1/5
 40.0.0.0/32 is subnetted, 1 subnets
O    40.0.0.1 [110/179] via 172.16.0.2, 00:03:11, Serial1/2
C    192.168.1.0/24 is directly connected, FastEthernet0/0
O    192.168.2.0/24 [110/65] via 172.16.0.2, 00:03:13, Serial1/2
O    192.168.3.0/24 [110/115] via 172.16.0.2, 00:03:14, Serial1/2
 30.0.0.0/32 is subnetted, 1 subnets
O    30.0.0.1 [110/115] via 172.16.0.2, 00:03:16, Serial1/2
R1#
```

Figure 5.10: GNS3 Simulator – Routing Table for R1 [OSPF]

The neighbor and the topology table for router R4 are: -



```
Dynamips(1): R1, Console port
R1#
R1#
R1#
R1#
R1#show ip ospf neighbor
Neighbor ID      Pri   State           Dead Time   Address        Interface
50.0.0.1         0     FULL/-          00:00:33    172.20.0.1     Serial1/5
20.0.0.1         0     FULL/-          00:00:34    172.16.0.2     Serial1/2
R1#
R1#
R1#
R1#sh ip ospf database
                OSPF Router with ID (192.168.1.1) (Process ID 1)

                Router Link States (Area 0)

Link ID          ADV Router      Age             Seq#            Checksum Link count
20.0.0.1         20.0.0.1       1035            0x80000005     0x00824C   6
30.0.0.1         30.0.0.1       829             0x80000005     0x007483   6
40.0.0.1         40.0.0.1       597             0x80000005     0x009252   6
50.0.0.1         50.0.0.1       581             0x80000004     0x00556B   6
192.168.1.1     192.168.1.1    580             0x80000005     0x00A306   5
R1#
R1#
R1#
R1#
R1#
R1#
```

Figure 5.11: GNS3 Simulator – Neighbor and Topology table for R1 [OSPF]

The neighbor table show only two entries as the router R4 is directly connected to only two routers and it also displays their ip address and the exit interface to reach the router.

The database /topology table contains details of the routers in the topology including their age, sequence number, checksum value and link count.

CHAPTER – 6

CONCLUSION

The analysis of the routing protocols has been done in a detailed way in two of the most advanced simulators i.e. GNS3 and OPNET. These two simulators can help in simulating the real world scenario which helps in determining flaws in the network and can also help in creating a network before implementing in the real world. Such use of simulators can help the network administrator in a large way to reduce to the future work load. The routing protocols that has been used in this thesis are RIP and OSPF. In this thesis for a better comparison to happen one protocol from distance vector and one protocol from link state has been used. Using these protocols helps in finding the best possible shortest path from the available paths from the source router to the destination router. The source router send update messages to its neighbor routers and receives update messages from other routers and by using the respective algorithm of the protocol implemented in the router, it calculates the best path to reach the remote network. This thesis result gives the routing table comparison of different routers in the network. This thesis is the result of the thorough understanding of the use of the two simulators and the routing protocols without which it would not have been possible to complete the thesis.

CHAPTER - 7

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